

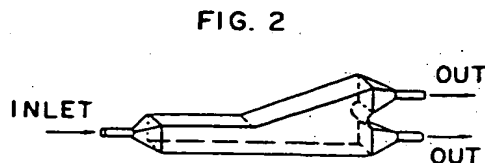
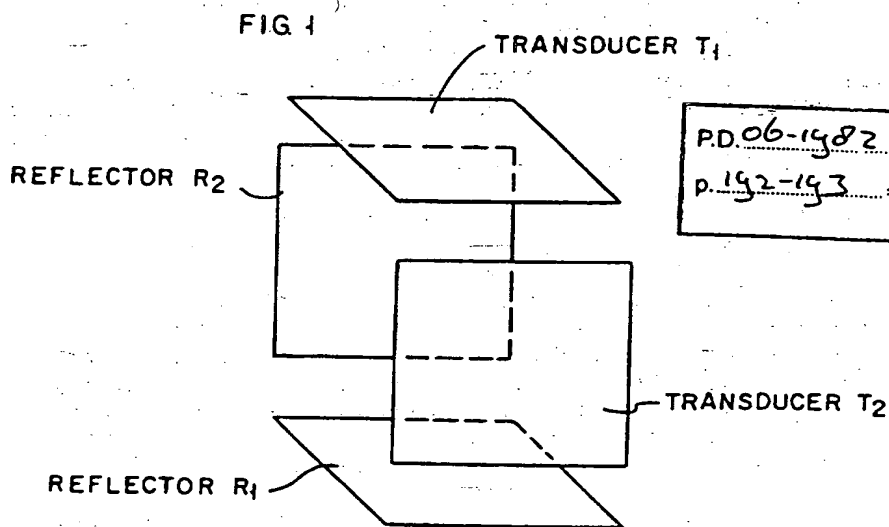
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ULTRASONIC CONTINUOUS FLOW PLASMAPHERESIS SEPARATOR

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This article relates generally to the separation of a material suspended in a fluid from the fluid and more specifically to the separation of emulsions in which the total volume of the dispersed phase is a small fraction of the total fluid volume. Still more specifically, it relates to the separation of certain particulate suspensions, for example, dilute (less than 1% hemat crit) blood. Separation of the character described may be carried out using ultrasonic transducers and a chamber having a special configuration.

In Fig. 1, two planar ultrasound transducers T₁, T₂, resonant at approximately 1 MHz, are mounted orthogonally, and each is spaced

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several centimeters from plane-reflecting surfaces R1,R2. This assembly is immersed in water as a sound conducting medium. Application of 1-MHz electrical excitation to transducers T1,T2 causes two orthogonal sets of standing waves to be set up in the liquid volume enclosed by the transducers T1,T2 and reflectors R1,R2. Within this volume, a chamber, as shown in Fig. 2, is placed. The chamber walls are made of thin, low-attenuation acoustic material. A dilute suspension or emulsion to be separated is forced into the chamber at the edge of the volume acted on by the orthogonal ultrasound fields via an inlet port. Two output ports are at the opposite side of the standing wave region.

If dilute blood in a thin-wall chamber is placed in the acoustic standing wave field set up between a single transducer and reflector, the red cells migrate under the influence of acoustic forces into a set of parallel sheets of high cell density. These parallel plane sheets have adjacent planes separated by one-half wavelength. With the orthogonal fields of this article, the dilute blood suspension will form filaments of cells along the intersection of the half-wavelength-spaced orthogonal planes, and will be held as filaments regardless of the direction of the gravity vector through the apparatus. The chamber of Fig. 2 is oriented such that its base is parallel to the R1-T1 pair, and its sides are parallel to the R2-T2 pair. When dilute blood is admitted slowly into the inlet port, the filaments of closely packed red cells form and are slowly transported to the lower output port. Excess plasma/saline, swept free of red cells, moves upward between the filaments and flows out of the upper port.

Acoustic power levels below values that cause cavitation and streaming must be used, resulting in rather weak separation forces. Flow velocities must therefore be very low to prevent viscous drag from disrupting the filaments and moving particles (cells) upward, contaminating the otherwise pure fluid leaving the upper port.